Arctic Oscillation and Polar Vortex Analysis and Forecasts

January 23, 2023

Dear AO/PV blog readers:

We have shifted the public release of the Arctic Oscillation/Polar Vortex blog to Wednesday through the winter season.

For those who would like an early look on Mondays, we will be offering at a nominal price (US $50) a PDF version of the upcoming blog, and we will be rolling out access to the datasets used in the production of this blog. At present we plan to make available in comma-separated values the timeseries of the Polar Cap Height and the timeseries of the Wave Activity Flux (vertical component), though we would appreciate to hear your suggestions for additional data of interest to you all.

Dr. Judah Cohen from Atmospheric and Environmental Research (AER) embarked on an experimental process of regular research, review, and analysis of the Arctic Oscillation (AO) and Polar Vortex (PV). This analysis is intended to provide researchers and practitioners real-time insights on one of North America's and Europe's leading drivers for extreme and persistent temperature patterns.

During the winter schedule the blog is updated once every week. Snow accumulation forecasts replace precipitation forecasts. Also, there is renewed emphasis on ice and snow boundary conditions and their influence on hemispheric weather. With the start of spring we transition to a spring/summer schedule, which is once every two weeks. Snow accumulation forecasts will be replaced by precipitation forecasts. Also, there will be less emphasis on ice and snow boundary conditions and their influence on hemispheric weather.

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The AO/PV blog is partially supported by NSF grant AGS: 1657748.

Summary

- The Arctic Oscillation (AO) is currently neutral and is predicted to straddle neutral over the next two weeks as pressure/geopotential height anomalies across the Arctic are currently and are predicted to remain mixed. The North Atlantic Oscillation (NAO) is currently neutral and is predicted to become increasingly positive the next two weeks as pressure/geopotential height anomalies are currently mixed but are predicted to become increasingly negative across Greenland the next two weeks.
- The next two weeks predicted ridging/positive geopotential height anomalies in eastern North Atlantic that extends across Northern Europe will anchor troughing/negative geopotential height anomalies across Southern Europe This pattern will generally favor normal to below normal temperatures across Southern Europe with normal to above normal temperatures across Northern Europe. This week it is cold across much of the the United Kingdom (UK) with a warming trend predicted.
- This week troughing/negative geopotential height anomalies are predicted to dominate Asia with ridging/positive geopotential height anomalies mostly limited to Northwest Russia and Southcentral Asia however next week ridging/positive geopotential height anomalies will expand across Western and Northern Asia with troughing/negative geopotential height anomalies becoming more limited to East Asia. This pattern favors widespread normal to below normal temperatures across Asia with normal to above normal temperatures limited to Northwestern and Southcentral Asia however next week normal to above normal temperatures will become more widespread across Northern and Western Asia with normal to below normal temperatures across Southern and Eastern Asia.
- The general pattern predicted across North America the next two weeks is ridging/positive geopotential height anomalies centered in the Gulf of Alaska and Alaska forcing deepening troughing/negative geopotential height anomalies cross the interior of North America with more ridging/positive geopotential height anomalies in the Southeastern United States (US). This pattern favors this week normal to above normal across Alaska and the Southeastern US with normal to below normal temperatures spreading from west to east across much of Canada and the US.
- I discuss the predicted complex polar vortex (PV) disruption and its impacts on Northern Hemisphere (NH) surface temperatures. I admittedly continue to struggle anticipating the impacts but impacts from a stretched PV are most likely.

Plain Language Summary

The one certainty this winter is a stretched polar vortex (PV) that favors a cold pattern east of the Rockies in North America. Another stretched PV is happening this week, with the cold arriving this week and likely to continue into early February. Following the stretched PV, a larger PV disruption is likely that could bring a return of the cold to North America, Asia and/or Europe following an interlude of milder weather. But much

uncertainty surrounds this event so my best advice is “the trend is your friend” (see **Figure v**).

Impacts

First another mea culpa from me in Wednesday’s update. I asked this rhetorical question, “what is going to prevent a major SSW?” I should have followed the question up with what I replied on Twitter immediately after posting the Wednesday update, troughing in the Ural-Scandinavian region (see Cohen reply 18Jan2023 on Twitter). That was an important caveat that should have been included in the blog. The obvious reason is - that is exactly what has transpired with the weather model forecasts. As soon as the Ural/Scandinavian ridging that they were predicting flipped to Ural/Scandinavian troughing all the weather models have backed off on the magnitude of the upcoming sudden stratospheric warming (SSW). A minor SSW still looks very likely (where the winds fail to reverse at 60°N and 10 hPa but there is warming of the polar stratosphere), and a major SSW is still possible (where the zonal-mean zonal wind winds at 60°N and 10 hPa), but the odds have clearly decreased substantially. But for the past two winters if there is one behavior of the polar vortex (PV) that we can count on – it is for the PV to stretch.

I think the two different changes in the tropospheric pattern that contributed to the model forecast changes are: the first is what I discussed in the blog from 9 January a shortening of the tropospheric wavelength. The second is the ridging in the Ural/Scandinavian region giving way to troughing. Like last week, I will first discuss first what is easier, the stretched PV and then try to tackle the more challenging forecast the impact from the predicted SSW.

The ongoing stretched PV looks “textbook” in my opinion, the only problem being that I am pretty sure you won’t find “stretched PV” in any meteorological textbook! We have amplified flow/waviness over Eurasia over the past week or so, strong Ural ridging with downstream troughing across East Asia (see **Figure i**). Meanwhile over North America the flow or waviness is more damped with nascent ridging in the Gulf of Alaska and weak troughing in Hudson Bay. This wave pattern is coupled with impressive cold in Asia while it is relatively mild across North America. But over the next two weeks the roles will reverse. The amplified flow and deep cold over Asia will moderate while the flow will amplify, and the cold deepen over North America.

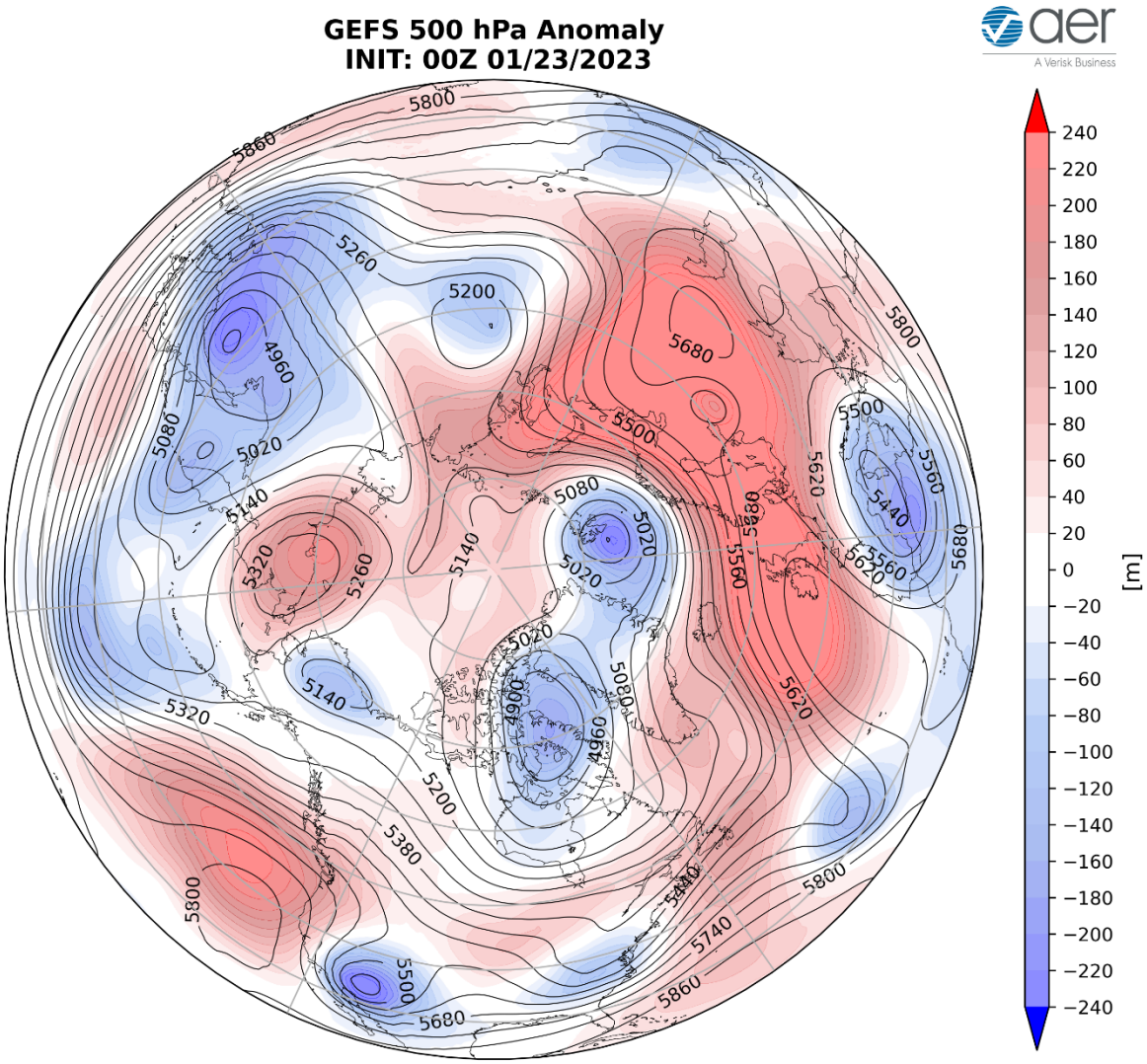

Figure i. Analyzted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for 23 January 2023. The forecasts are from the 00z 23 January 2023 GFS ensemble.

One other thing that has changed is the wave diagnostics that I have been posting this winter. Unfortunately, the model forecasts of Wave Activity Flux (WAFz) from the troposphere to the stratosphere have been quite volatile. But as I have been doing all month, I show in **Figure ii** the predicted WAF in the vertical and latitudinal directions. You can easily make out WAF that is upward and eastward over Asia and the North Pacific and then eastward and downward over North America. This is the signature sign of wave reflection/stretched PV. But where previous forecasts show the reflection transitioning to full WAF absorption in the stratosphere, the GFS forecast is now showing persistent wave reflection from today through the first week of February. Hard to get a major SSW if reflection is also occurring. And as I was anticipating for at least a couple of weeks now, the forecasts have trended colder across the US east of

the Rockies for late January and into early February. And I still believe extreme cold remains a possibility.

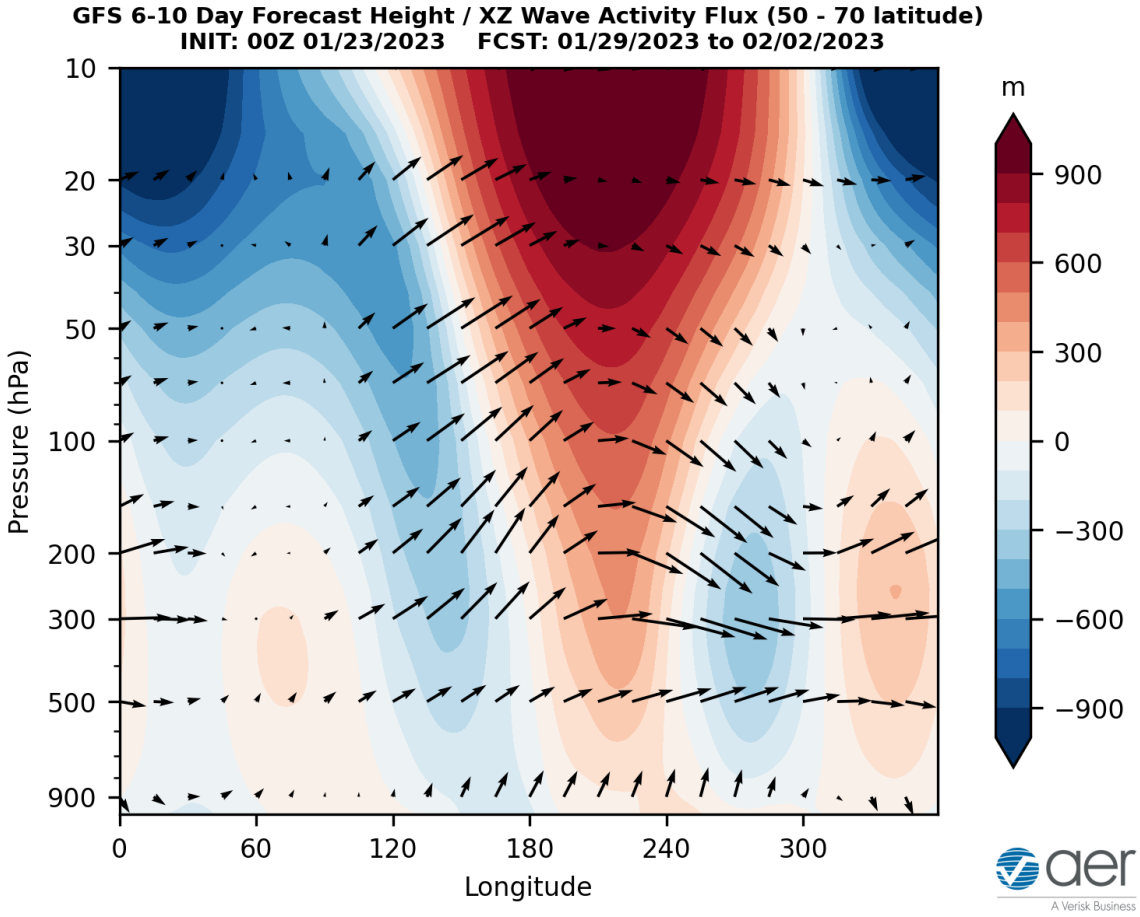

Figure ii. Longitude-height cross section of geopotential eddy height anomalies (shading) and wave activity flux (vectors) forecasted for 29 January – 2 February 2023. The forecasts are from the initialized 0z 23 January 2023 GFS ensemble.

In fact, our machine learning (ML) model from this morning (though based on data only through 17 January2023) is predicting a cold pattern east of the Rockies across the US for the first full two weeks of February (see **Figure iii**). So far this winter I think that the ML model has correctly anticipated temperature transitions but has had some timing

issues.

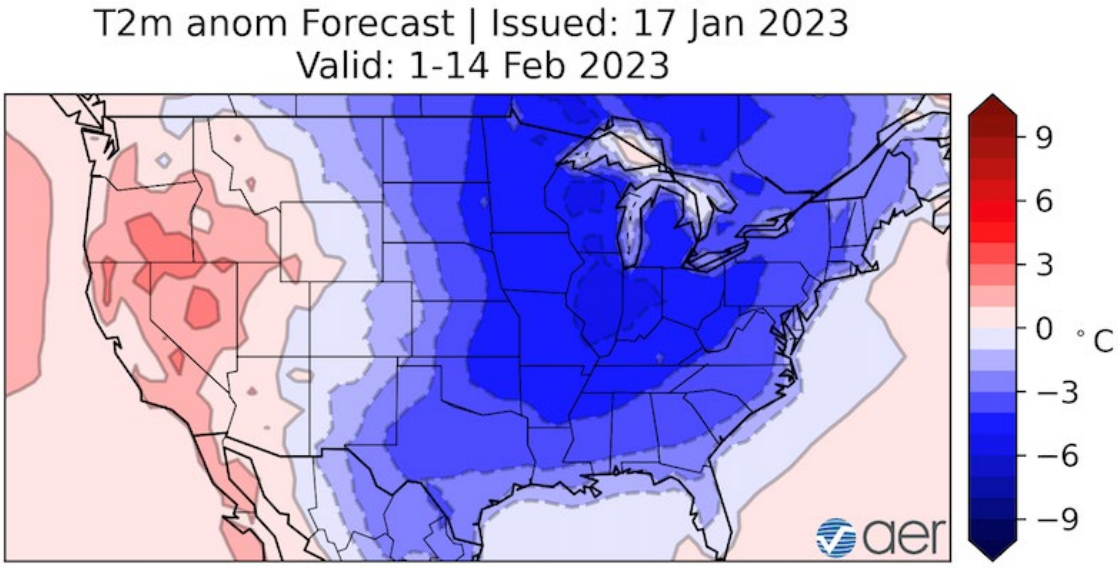

Figure iii. Machine Learning (ML) model surface temperature anomalies (°C; shading) forecast for 1 – 14 February 2023. Observational data used for the forecast through 17 January 2023.

That's the easy part but what about the impacts from the upcoming SSW (even if minor). First if you look below at **Figure 5**, there is this trough over Europe that seems to come out of nowhere. I would argue that is a reflection of the PV center moving over Europe (see **Figure 13b**) and is an immediate impact of the SSW as I speculated about in Monday's blog from last week (16January2023). Troughing and cold temperatures have come to Europe. Nothing as extreme as Asia or what is coming to North America but a clear change from the weather Europe has experienced since late December.

And even though this will only likely be a minor SSW I do think that there will be delayed impacts. In January or February 2011, 2012, 2014, 2015, 2016 and 2017 a minor SSW was observed. I would argue that there was a turn to more severe winter weather following those minor SSWs with the possible exception of 2016. Sometimes the impact was of shorter duration (e.g. 2017) and some were longer (e.g., 2014 and 2015). Some of those minor SSWs, I would argue were really more amplified stretched PVs and it is possible that might be a better way to ultimately understand the ongoing PV disruption.

In **Figure iv,** I show predicted WAF in the vertical and longitudinal directions along with the zonal-mean zonal wind. I show this figure to make two points. The first is that the wind reversal (negative or easterly wind) from the surface into the upper stratosphere from 70°N to the North Pole. There is a reversal of the wind at 70°N but not at 60°N, how important is that difference I don't know. The second point is that the deceleration

of the winds reaches into the stratosphere with the strongest deceleration in the upper stratosphere. This seems to me an ideal environment for more reflective PV stretched events. As I discussed last week, I expect downward propagation of warm positive polar cap geopotential height anomalies (PCHs). No sign of it yet in today's GFS forecast (see **Figure 11**) but that forecast looks bizarre to me and I don't trust it.

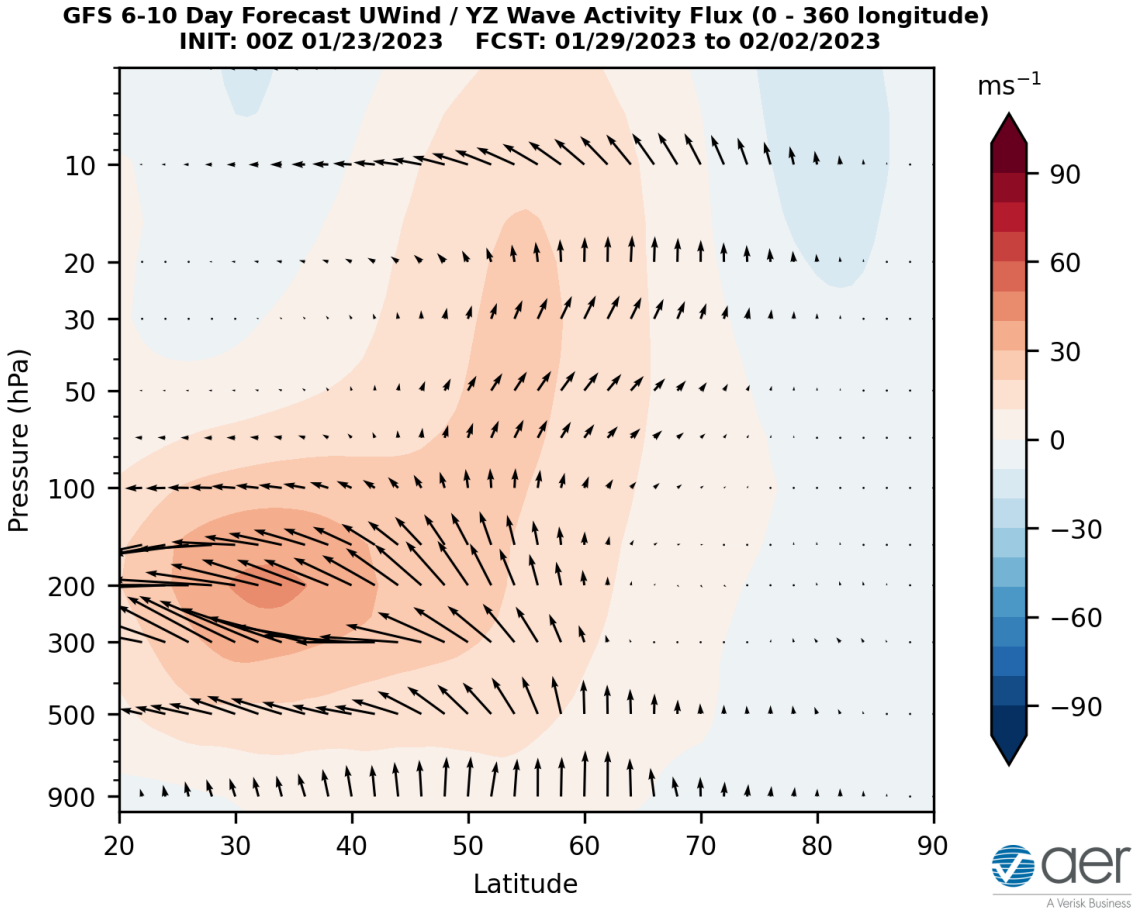

Figure iv. Latitude-height cross section of zonal-mean zonal wind (shading) and wave activity flux (vectors) forecasted for 29 January – 2 February 2023. The forecasts are from the initialized 0z 23 January 2023 GFS ensemble.

I want to be less flippant this week compared to last so I will keep my conclusions about the upcoming weather brief. Typically, the impacts from stretched PV events on the weather lasts about a week and up to two weeks for the largest events. But it seems to me that the minor SSW could extent that impact for a longer period with a possible milder interlude included in an overall colder period for the remainder of the winter. And given all the uncertainty with the PV my fallback operating principle is "the trend is your friend." In February, a strong cooling trend has been observed over the US especially down the center of the country. Don't take my word for it, in **Figure v** I show the February temperature trend analysis from Brian Brettschneider

(@Climatologist49). Seems as reasonable a forecast as any.

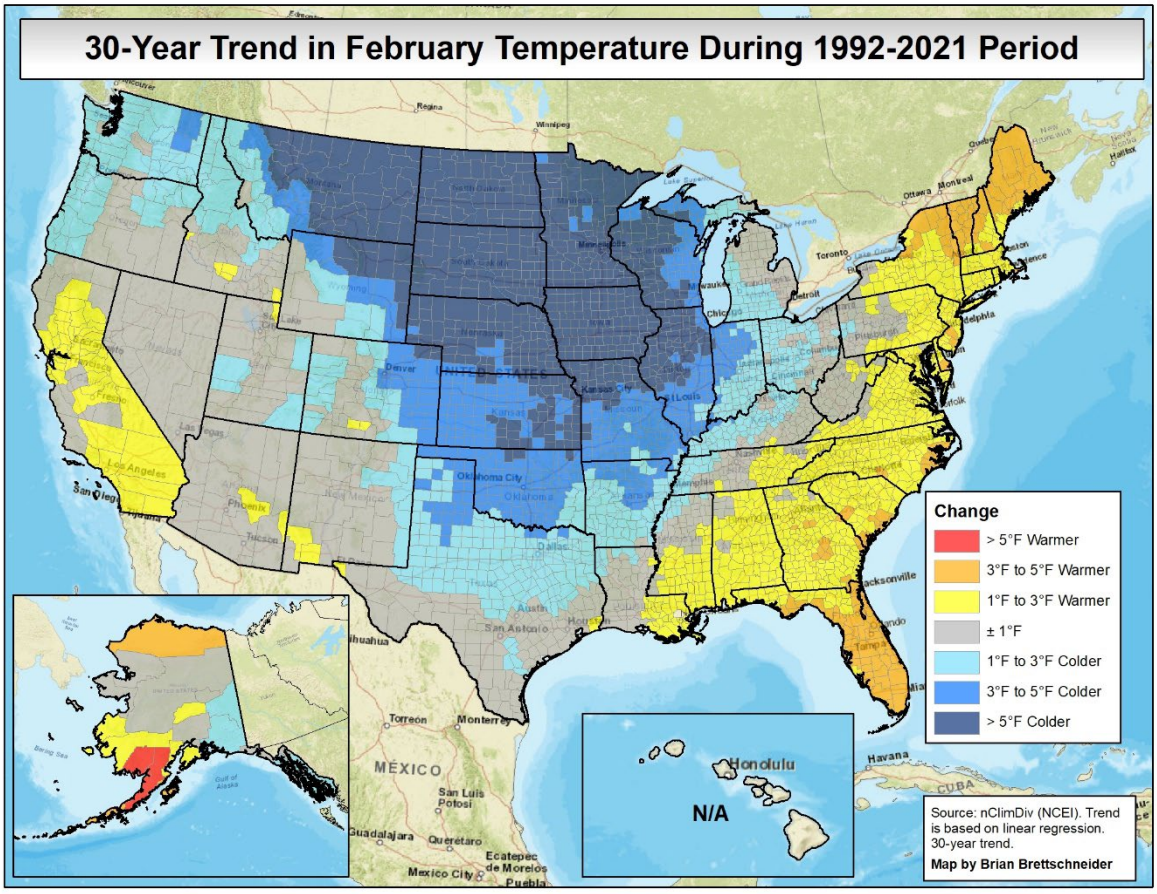

Figure v. Observed surface temperature trend (°F; shading) for the US based on station data from Brian Brettschneider (@Climatologist49).

I would just add a major SSW could follow a minor SSW as happened most recently in 2016.

Wednesday Update

I think the theme from Monday continues today, the upcoming disruption of the PV should be considered less like a classical SSW and more like a stretched PV. The PV has taken on an oblong shape and the elongated or stretch shape will persist at least through the end of the month. The largest negative temperature departures were previously in Asia and are predicted to be in North America through the first week of February. Though an SSW is still very likely to occur (should verify imminently and the NASA model is even predicting a daily record high temperature for the North Pole at 10hPa!), at least the GFS seems to be predicting a less impressive event with each subsequent model forecast. By early February the PV is pretty much back to normal

with the PV centered near the North Pole and circular in shape (see **Figure vi**).

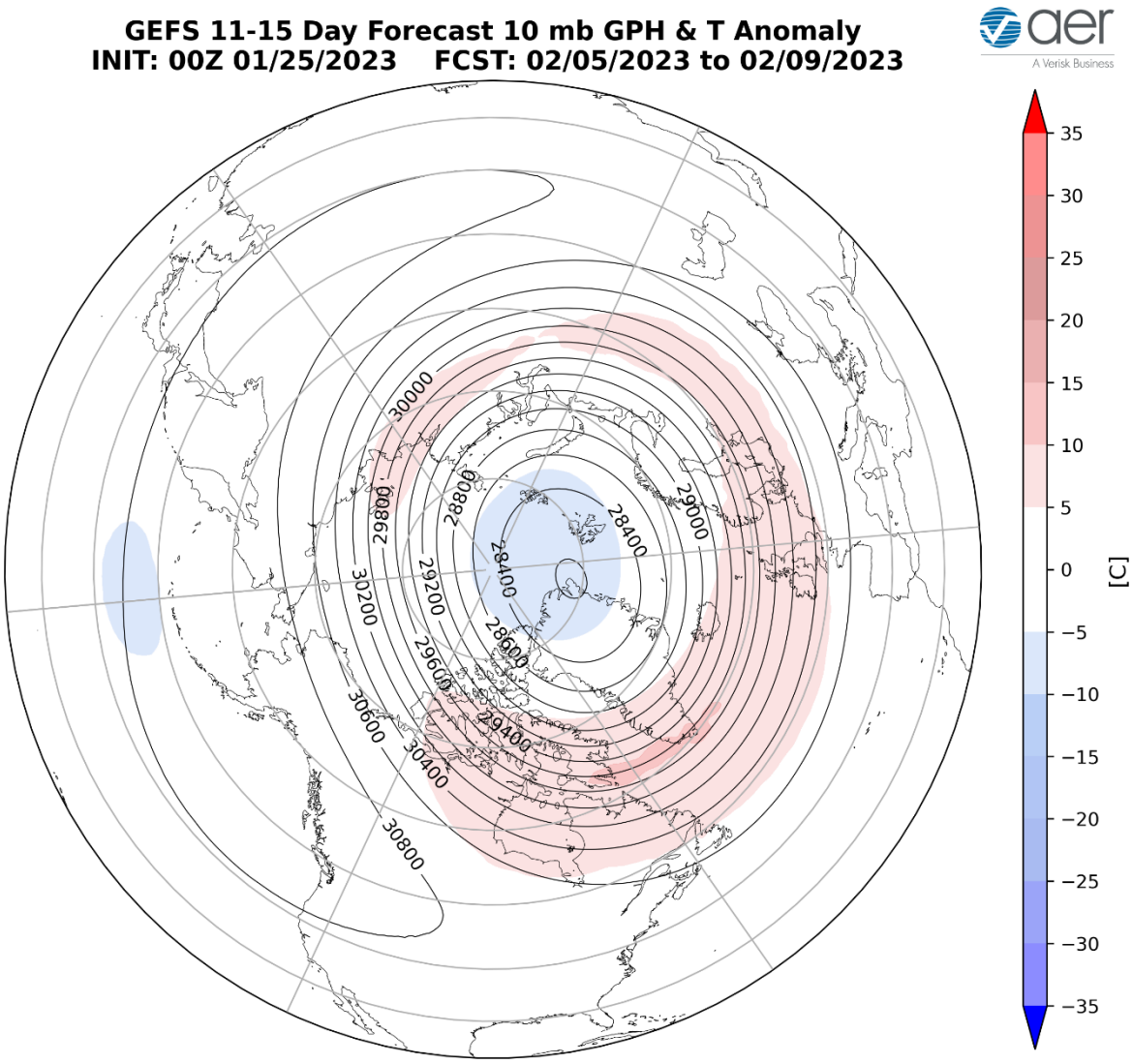

Figure vi. Forecasted 10 mb geopotential heights (dam; contours) and temperature anomalies (°C; shading) across the Northern Hemisphere from 5 – 9 February 2023. The forecasts are from the 00Z 25 January 2023 GFS model ensemble.

But the impacts from stretched PVs usually last about a week maybe up to two weeks for the strongest events and given that the PV will be relatively weak for the next week or so, this may be a stronger event. But whether the weather impacts last a week or two what comes next. I often look to the GFS PCH forecast for clues. I included the one from this morning (see **Figure vii**), but it still looks very strange to me. There is no visible downward propagation of warm/positive PCHs from the stratosphere to the troposphere yet warm/positive in the lower troposphere appear all the same. This is like sitting down to a meal skipping the entree and going straight to dessert. If you are a kid this might be very appealing, but you might be incredulously looking at your

parents trying to figure out if this is a trick. The same with me, I cannot find any analogs to the GFS forecast and my attitude is yes “never say never” but also “I will believe it when I see it.”

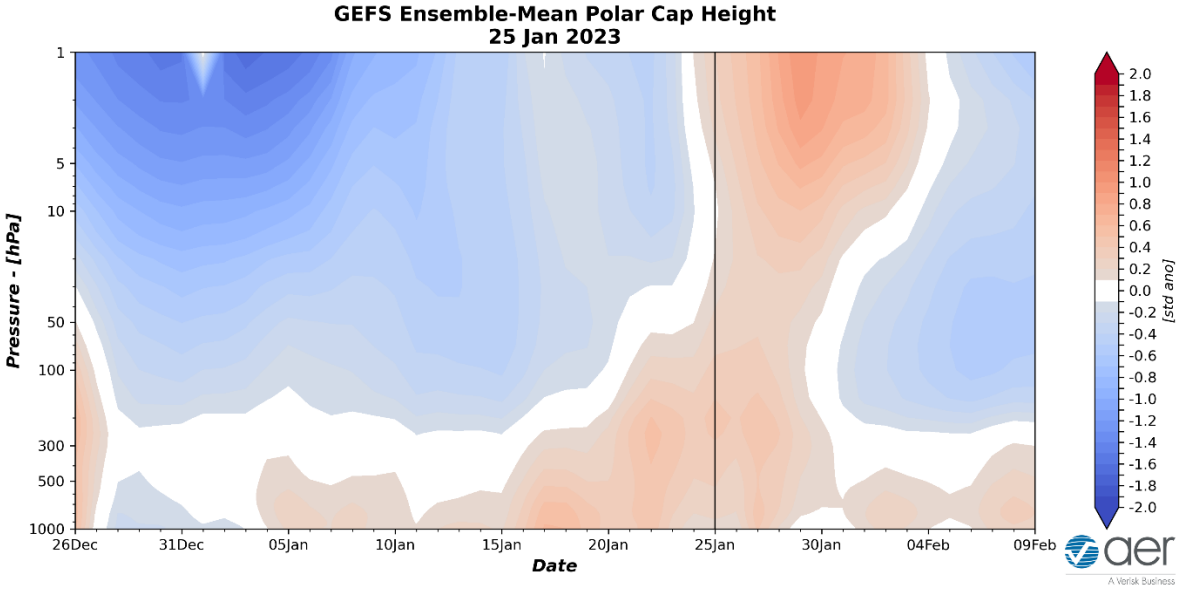

Figure vii. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecast is from the 00Z 25 January 2023 GFS ensemble.

And though Ural blocking/ridging is currently absent, it does seem that the models are predicting a good chance that it will return by early February, the atmospheric feature most conducive to disrupting the PV in my opinion. So even as the PV strengthens in early February, I do think that additional disruptions of the PV are possible. And based on the latest GFS WAFz forecast (see **Figure vii**), the active WAFz period will persist at least for the next two weeks. Though both an SSW or stretched PV are possible, I am thinking stretched PV until forced to consider differently.

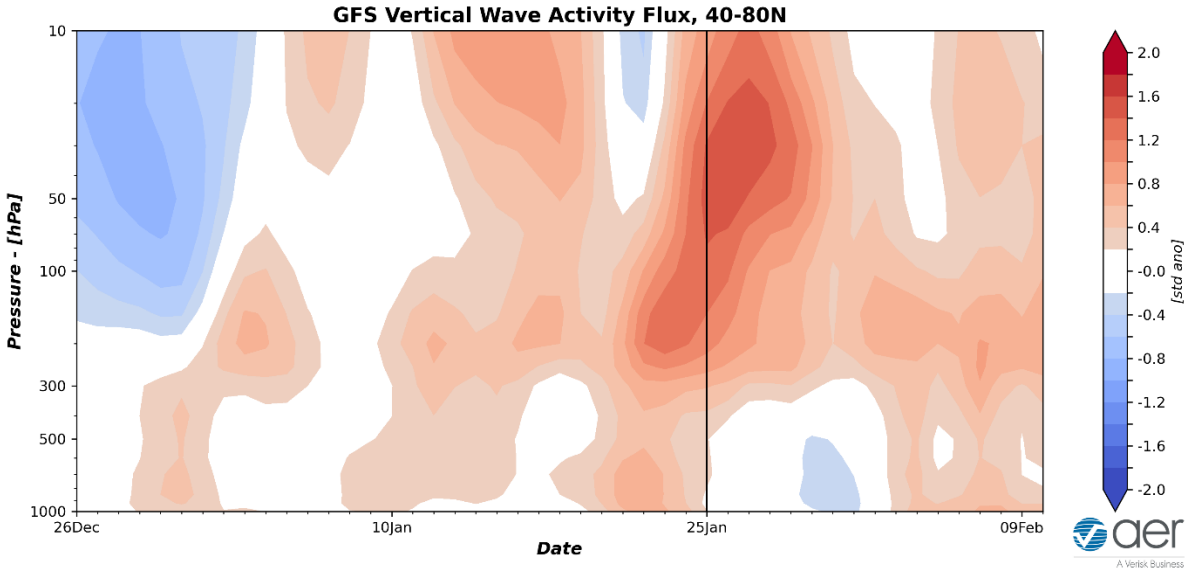

Figure 12. Observed and predicted daily vertical component of the wave activity flux (WAFz) standardized anomalies, averaged poleward of 40-80°N. The forecast is from the 00Z 25 January 2023 GFS ensemble.

Recent and Very Near Term Conditions

The AO is predicted to be neutral this week **(Figure 1**) mixed positive geopotential height anomalies predicted across the Arctic with mixed geopotential height anomalies across the mid-latitudes of the NH (**Figure 2**). And with mixed geopotential height anomalies this week across Greenland (**Figure 2**), the NAO is predicted to be neutral this week as well (**Figure 1**).

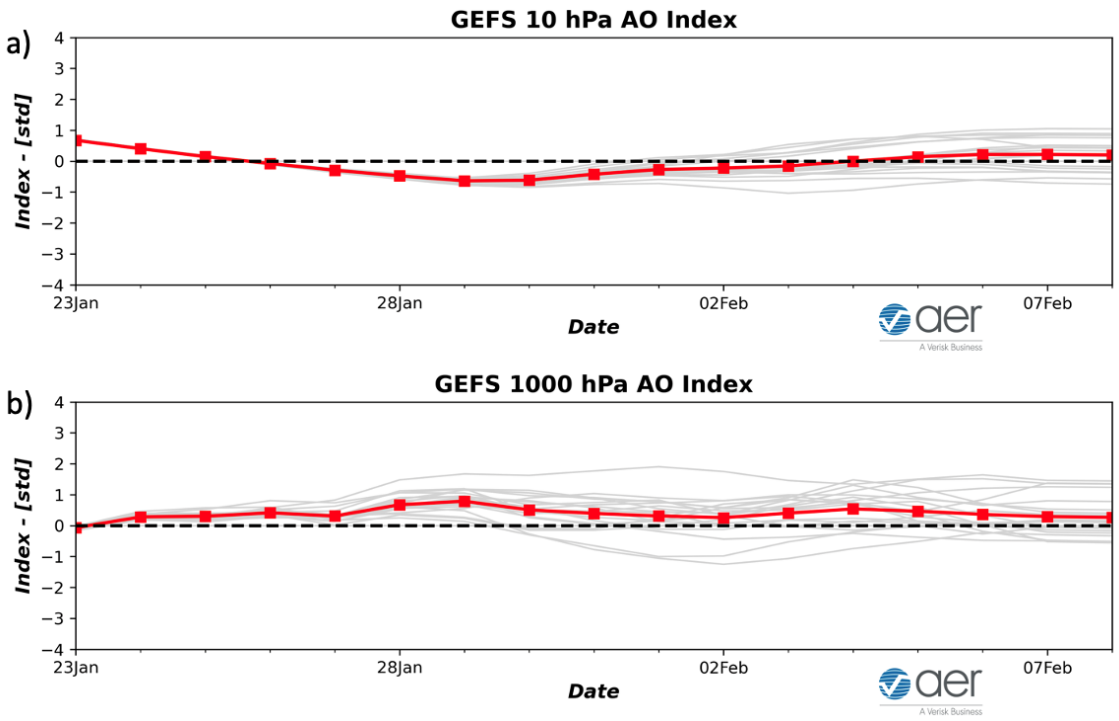

Figure 1. (a) The predicted daily-mean AO at 1000 hPa from the 00Z 23 January 2023 GFS ensemble. (b)The predicted daily-mean near-surface AO from the 00Z 23 January 2023 GFS ensemble. Gray lines indicate the AO index from each individual ensemble member, with the ensemble-mean AO index given by the red line with squares.

Predicted ridging/positive geopotential height anomalies centered in the eastern North Atlantic that extends eastward across Northern Europe will force troughing/negative geopotential height anomalies across Southern Europe this period (**Figure 2).** This pattern will favor normal to below normal temperatures across Western and Southern Europe including the UK with normal to above normal temperatures across Northern and Eastern Europe (**Figure 3**). Ridging/positive geopotential height anomalies centered in Northwestern Russia will favor troughing/negative geopotential height anomalies across Siberia and Eastern Asia with more ridging/positive across Southcentral Asia (**Figure 2**). This pattern favors normal to below normal temperatures across Siberia, Central and Eastern Asia with normal to above normal temperatures across Northwestern and Southcentral Asia including the Tibetan Plateau **(Figure 3**).

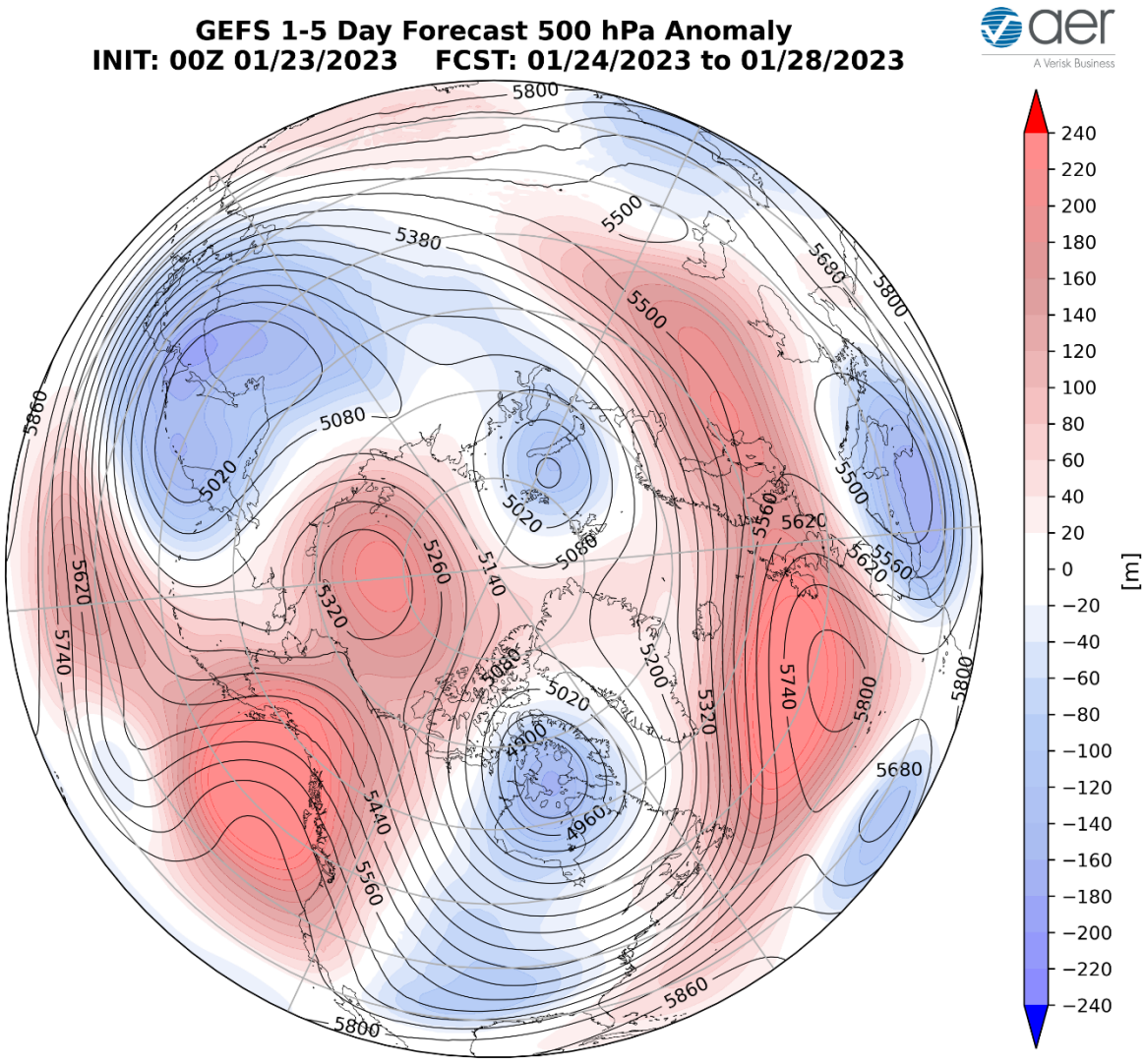

Figure 2. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 24 – 28 January 2023. The forecasts are from the 00z 23 January 2023 GFS ensemble.

The predicted pattern across North America this week is ridging/positive geopotential height anomalies centered in the Gulf of Alaska and Alaska forcing troughing/negative geopotential height anomalies across the interior of North America with more ridging/positive geopotential height anomalies across the east coast of North America **(Figure 2).** The pattern will favor normal to above normal temperatures across Alaska, Western Canada and the east coasts of Canada and the US with normal to below normal temperatures for Central and Northern Canada and the Western and Central US **(Figure 3).**

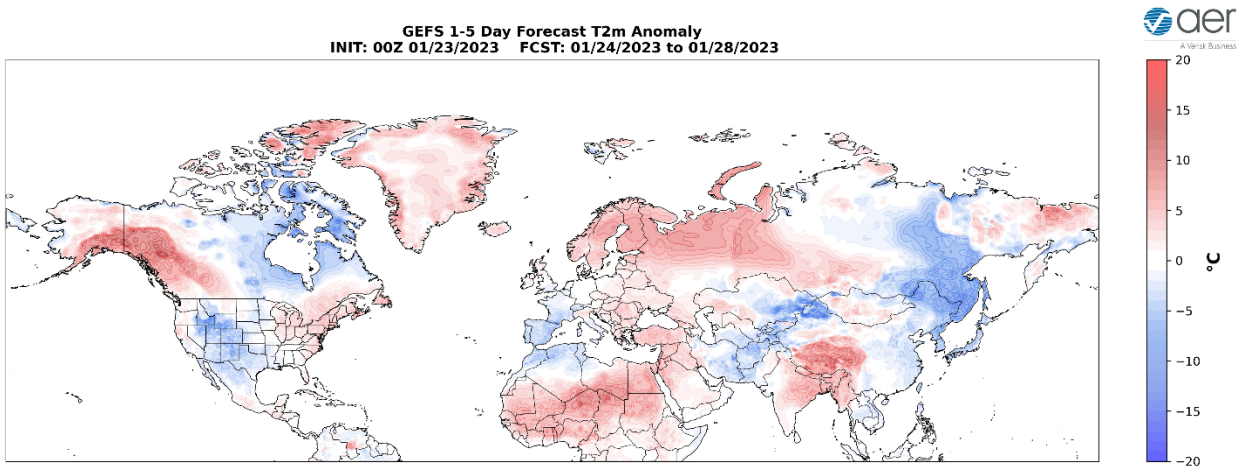

Figure 3. Forecasted surface temperature anomalies (°C; shading) from 24 – 28 January 2023. The forecast is from the 00Z 23 January 2023 GFS ensemble.

Troughing and/or cold temperatures will support new snowfall across the Balkans, Western Siberia, Central and East Asia while mild temperatures will support snowmelt across the Scandinavia, the Baltics and Northwestern Russia (**Figure 4**). Troughing and/or cold temperatures will support new snowfall across Alaska, Northern and Eastern Canada and the Northeastern US while mild temperatures will support snowmelt across the Western Canada and the Western US (**Figure 4**).

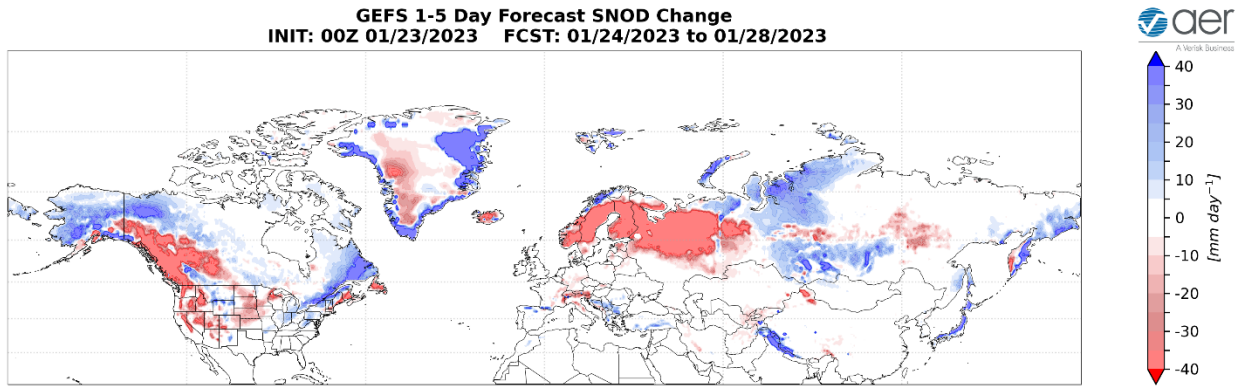

Figure 4. Forecasted snow depth changes (mm/day; shading) from 24 – 28 January 2023. The forecast is from the 00Z 23 January 2023 GFS ensemble.

Near-Term

1-2 week

The AO is predicted to remain close to neutral this period **(Figure 1**) as geopotential height anomalies continue mixed across the Arctic and mixed across the mid-latitudes

(**Figure 5**). With mostly troughing albeit weak geopotential height anomalies across Greenland (**Figure 5**), the NAO is predicted to turn weakly positive this period.

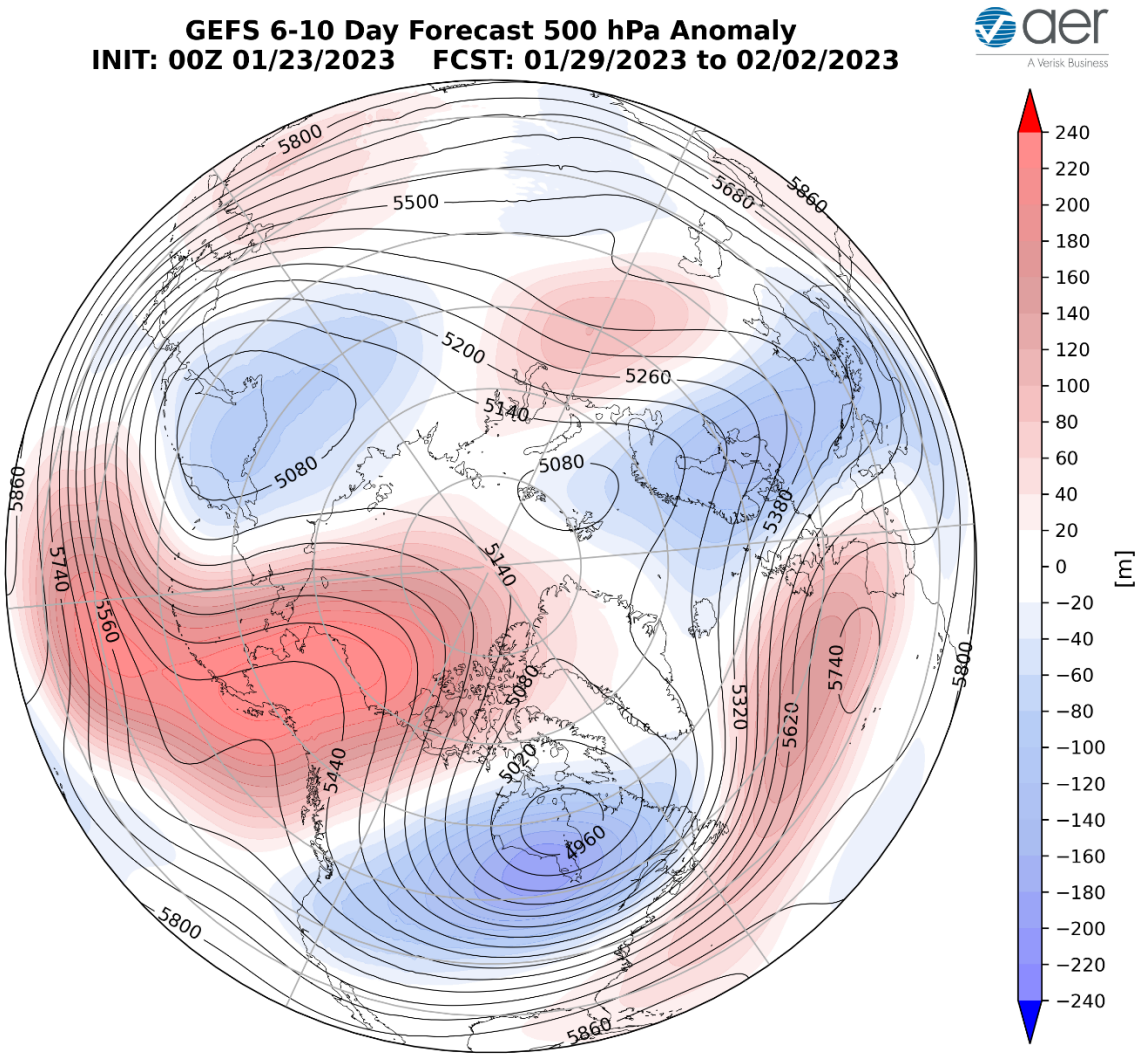

Figure 5. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 29 January – 2 February 2023. The forecasts are from the 00z 23 January 2023 GFS ensemble.

Persistent geopotential height anomalies centered in the eastern North Atlantic will support troughing/negative geopotential height anomalies across much of Europe (**Figures 5).** The expansion of troughing across Europe this period is a reflection of the PV over Europe **(**see **Figure 13b)** but seems to be fleeting. This pattern favors normal to above normal temperatures across Northern Europe including the UK with normal to below normal temperatures across Western and Southern Europe (**Figure 6**). Persistent ridging/positive geopotential height anomalies centered across Northwestern Russia

will anchor troughing/negative geopotential height anomalies across Siberia and Eastern Asia that extends southwestward into Central Asia with more ridging/positive geopotential height anomalies across Southeastern Asia this period (**Figure 5**). This pattern favors normal to below normal temperatures across much of Siberia, Northeastern and Central Asia with normal to above normal temperatures across Western and Southern Asia **(Figure 6**).

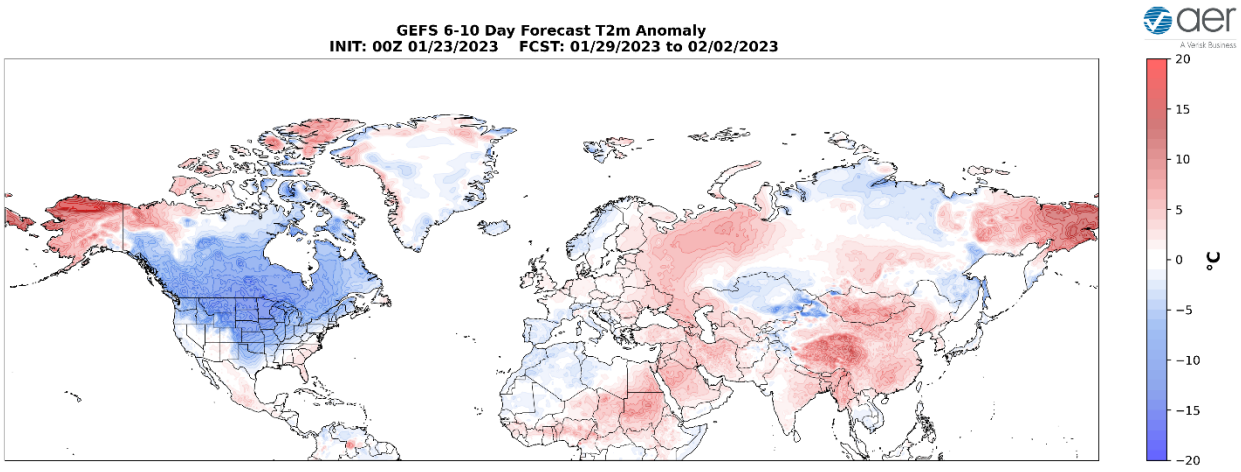

Figure 6. Forecasted surface temperature anomalies (°C; shading) from 29 January – 2 February 2023. The forecast is from the 00Z 23 January 2023 GFS ensemble.

Persistent ridging/positive geopotential height anomalies centered in the Gulf of Alaska and Alaska will support deepening troughing/negative geopotential height anomalies centered in the interior of North America with more ridging/positive geopotential height anomalies the Southeastern US this period **(Figure 5).** This pattern will favor normal to above normal temperatures across Alaska and the Southeastern US with normal to below normal temperatures across much of Canada and the US **(Figure 6).**

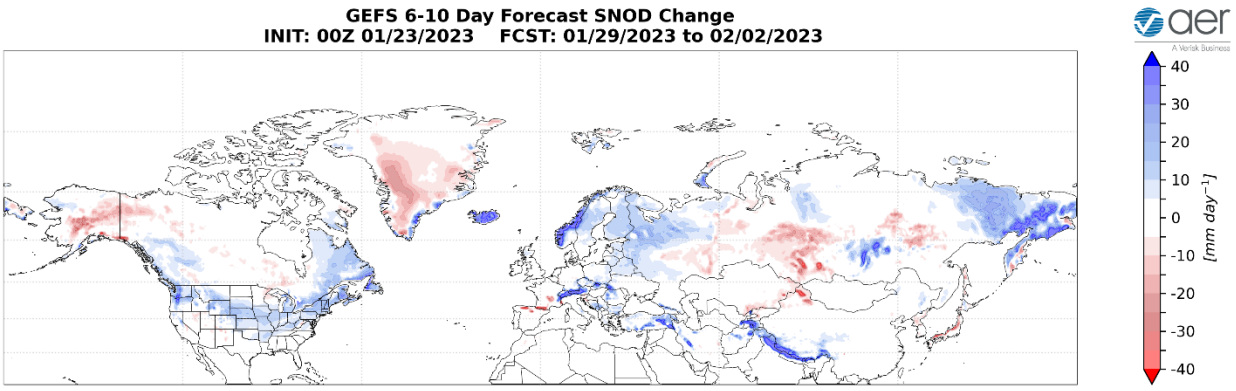

Figure 7. Forecasted snow depth changes (mm/day; shading) from 29 January – 2 February 2023. The forecast is from the 00Z 23 January 2023 GFS ensemble.

Troughing and/or cold temperatures will support new snowfall across Scandinavia, the Alps, Eastern Europe, Eastern Siberia and Central Asia while mild temperatures will support snowmelt in in the Urals and Central Asia (**Figure 7**). Troughing and/or cold temperatures will support new snowfall across Southern Canada and the Northwestern and the Northern US while mild temperatures will support snowmelt in Alaska (**Figure 7**).

3-4 week

With continued mixed to negative geopotential height anomalies across the Arctic and with mixed geopotential height anomalies across the mid-latitudes this period (**Figure 8**), the AO should remain tethered to neutral this period (**Figure 1**). With negative pressure/geopotential height anomalies across Greenland (**Figure 8**), the NAO will become solidly positive this period.

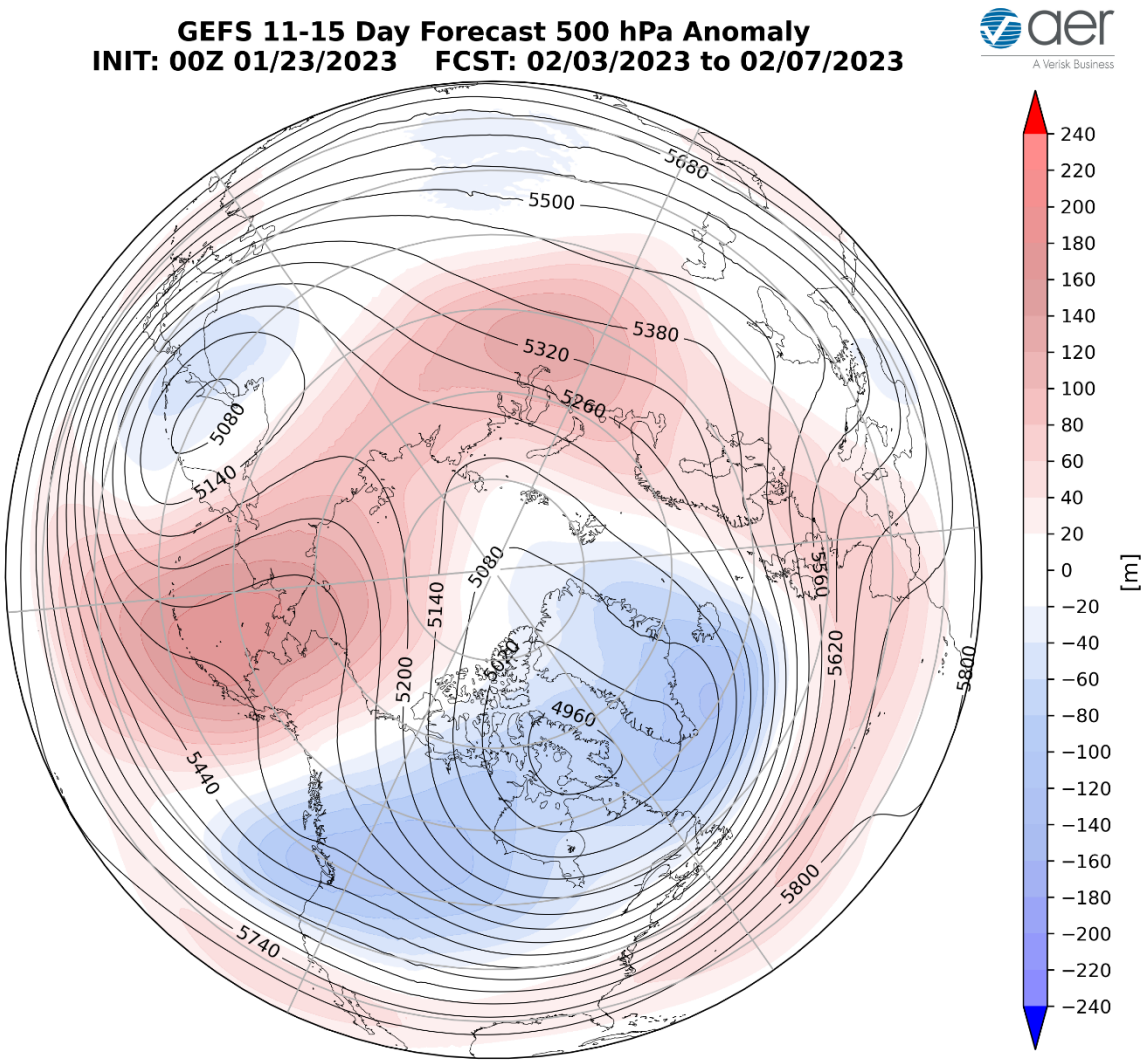

Figure 8. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere from 3 – 7 February 2023. The forecasts are from the 00z 23 January 2023 GFS ensemble.

Persistent ridging/positive geopotential height anomalies in the eastern North Atlantic will once again spread across with Northern Europe with troughing/negative geopotential height anomalies across Southern Europe this period (**Figure 8**). This pattern favors normal to above normal temperatures across Northern Europe including the UK with normal to below normal temperatures across Southern Europe (**Figures 9**). Persistent ridging/positive geopotential height anomalies across Northwestern Russia are predicted to spread across Siberia forcing troughing/negative geopotential height anomalies across Eastern and Central Asia (**Figure 8**). This pattern favors widespread normal to above normal temperatures across much of Asia with normal to below normal temperatures limited to Northeastern and Central Asia (**Figure 9**).

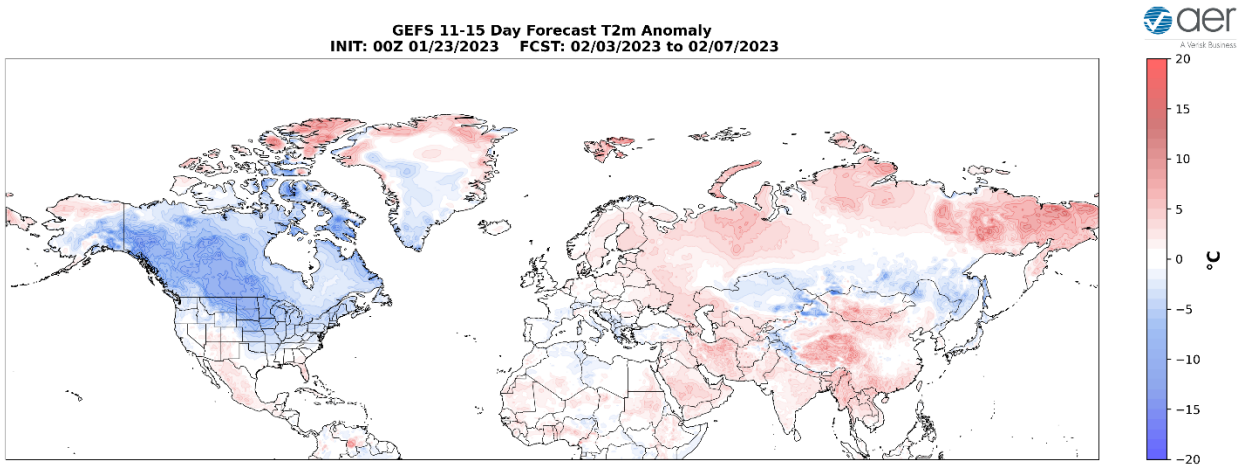

Figure 9. Forecasted surface temperature anomalies (°C; shading) from 3 – 7 February 2023. The forecast is from the 00Z 23 January 2023 GFS ensemble.

Predicted persistent ridging/positive geopotential height anomalies previously in the Gulf of Alaska extending north across Alaska and into the Beaufort Sea will now slide west towards the Aleutians and anchor troughing/negative geopotential height anomalies across the interior of North America this period (**Figure 8**). This pattern favors widespread normal to below normal temperatures across Canada and the US with normal to above normal temperatures limited to Alaska, the Southwestern US and Florida (**Figure 9**).

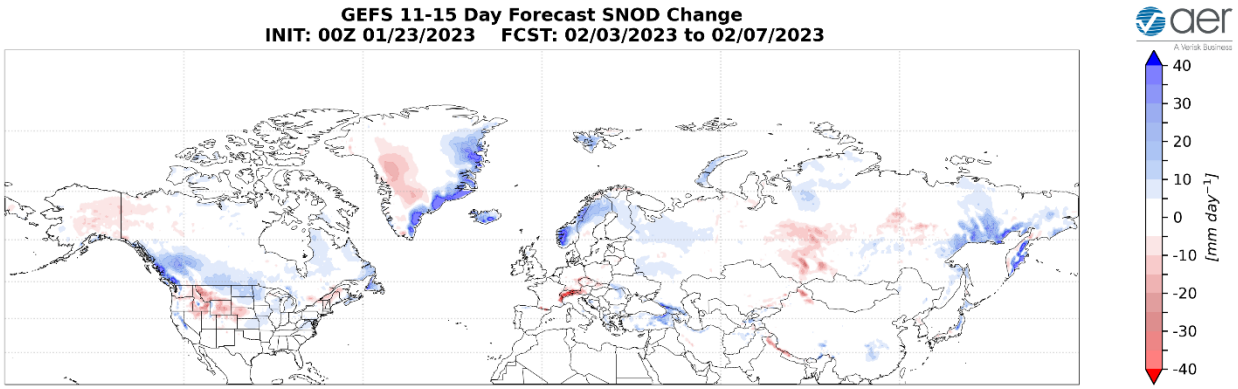

Figure 10. Forecasted snow depth changes (mm/day; shading) from 3 – 7 February 2023. The forecast is from the 00Z 23 January 2023 GFS ensemble.

Troughing and/or cold temperatures will support new snowfall across Scandinavia, Turkey, Northern and Eastern Asia while mild temperatures will support snowmelt in the Alps and Central Asia (**Figure 10**). Troughing and/or cold temperatures will support new snowfall across Southern Canada and the Northcentral while mild temperatures will support snowmelt in Alaska and the US Northern Rockies (**Figure 10**).

Longer Term

30–day

The latest plot of the polar cap geopotential height anomalies (PCHs) currently shows cold/negative PCHs throughout the stratosphere with warm/positive PCHs in the troposphere (**Figure 11**). However, the cold/negative PCHs in the stratosphere are predicted to turn warm/positive this week while warm/positive PCHs in the troposphere are predicted to strengthen and persist the next two weeks (**Figure 11**). The transition of cold/negative to warm/positive PCHs in the stratosphere is a sudden stratospheric warming (SSW).

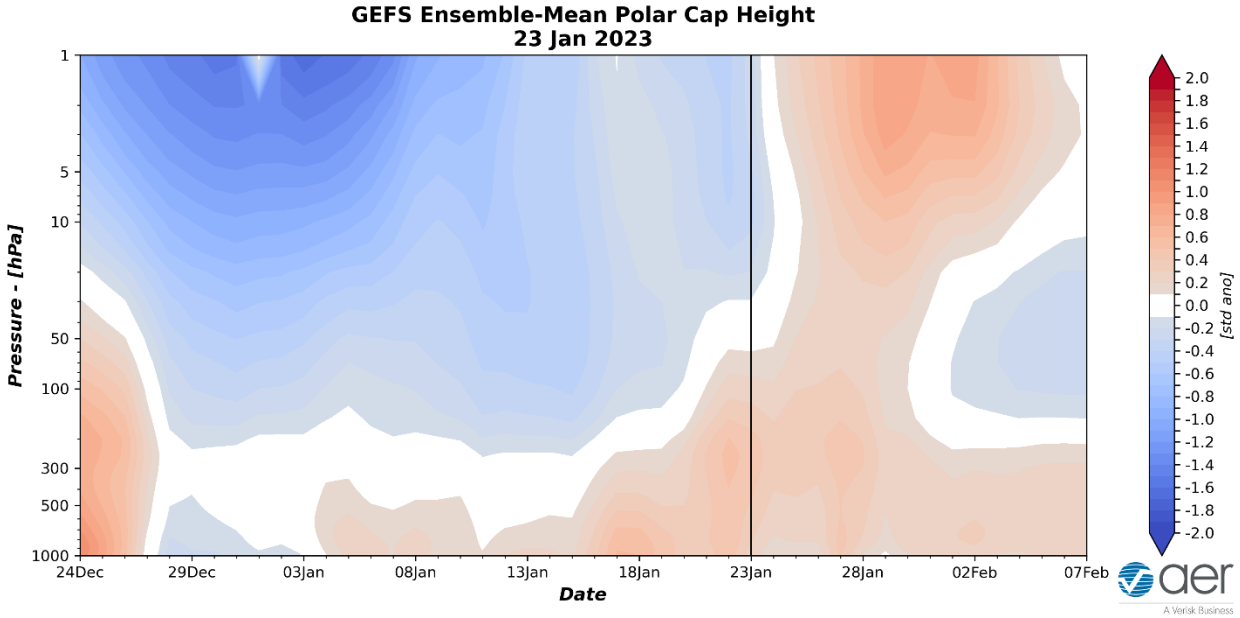

Figure 11. Observed and predicted daily polar cap height (i.e., area-averaged geopotential heights poleward of 60°N) standardized anomalies. The forecast is from the 00Z 23 January 2023 GFS ensemble.

The mostly warm/positive PCHs in the lower troposphere over the next two weeks (**Figure 11**) are consistent with the predicted near neutral surface AO (**Figure 1**). However next week when the warm/positive PCHs in the lower troposphere are predicted to weaken (**Figure 11**), the AO could become more positive (**Figure 1**).

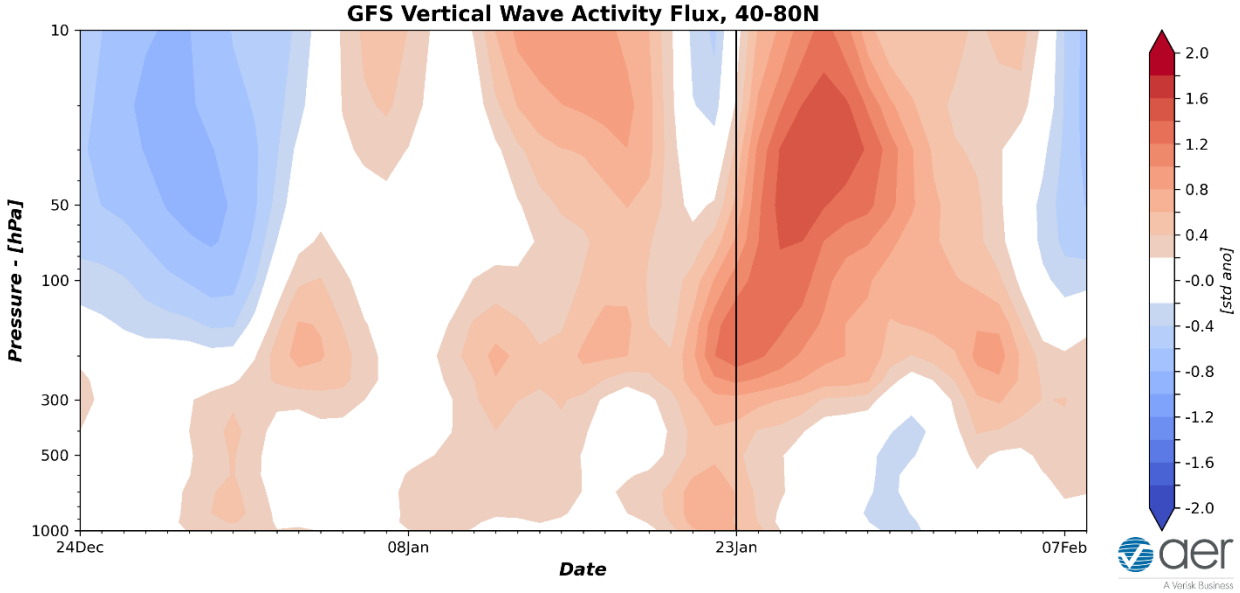

Figure 12. Observed and predicted daily vertical component of the wave activity flux (WAFz) standardized anomalies, averaged poleward of 40-80°N. The forecast is from the 00Z 23 January 2023 GFS ensemble.

Vertical Wave Activity Flux (WAFz) from the troposphere to the stratosphere or poleward heat transport in the stratosphere became more active the past two weeks (**Figure 12**) which has resulted in warming of the very cold/negative stratospheric PCHs from record and near record cold to just weakly cold (**Figure 11**). The GFS is predicting that the WAFz will become even more active this week and peak later this week (**Figure 12**), resulting in continued overall warming of the stratospheric PCHs through late January that should result in at least a minor sudden stratospheric warming (SSW) and could potentially achieve major SSW status, though a major SSW is looking unlikely at this point (**Figure 11**).

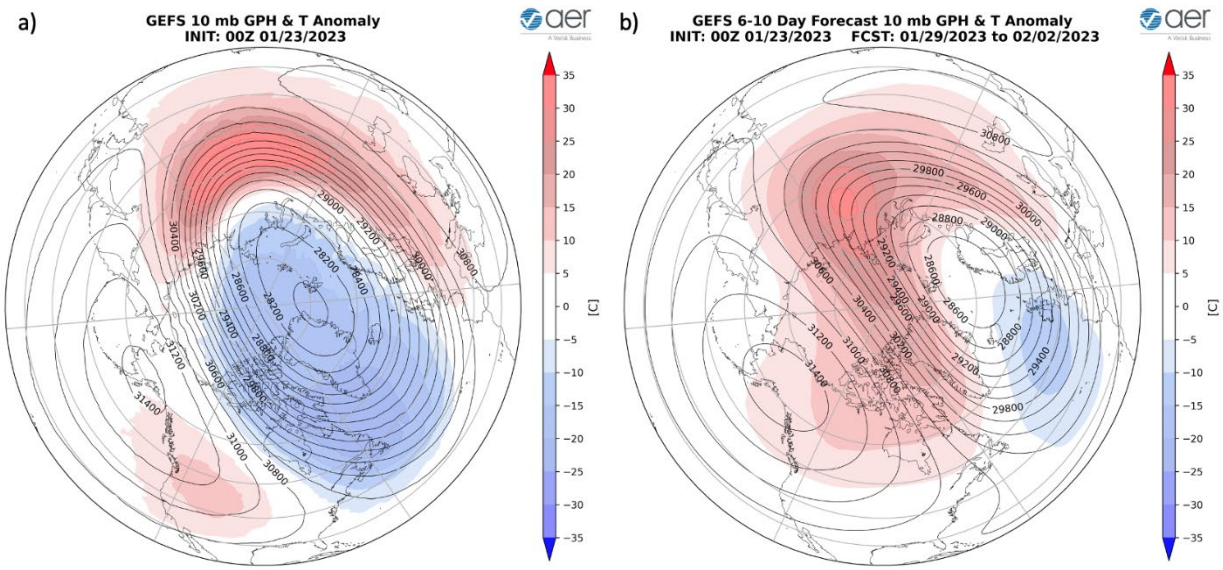

Figure 13. (a) Initialized 10 mb geopotential heights (dam; contours) and temperature anomalies (°C; shading) across the Northern Hemisphere for 23 January 2023. (b) Same as (a) except forecasted averaged from 29 January – 2 February2023. The forecasts are from the 00Z 23 January 2023 GFS model ensemble.

The more active WAFz has shifted the still strong stratospheric PV center over towards northeastern Greenland and has caused it to stretch or elongate **(Figure 13**). Coupled with the elongated PV is ridging and warming centered over Alaska in the polar stratosphere (**Figure 13**). The above normal WAFz predicted for the next ten days will continue to perturb the PV, with the PV shape remaining oblong but shifted into the Barents-Kara Seas/Scandinavia with additional warming/ridging exiting from Siberia into Greenland (**Figure 13**). These are all signs of a stretched PV that favor cold in eastern North America. However, the PV disruption could transition to one more

consistent with an SSW. The stratospheric AO is predicted to remain positive the next few days before finally dipping negative later this week (**Figure 1**).

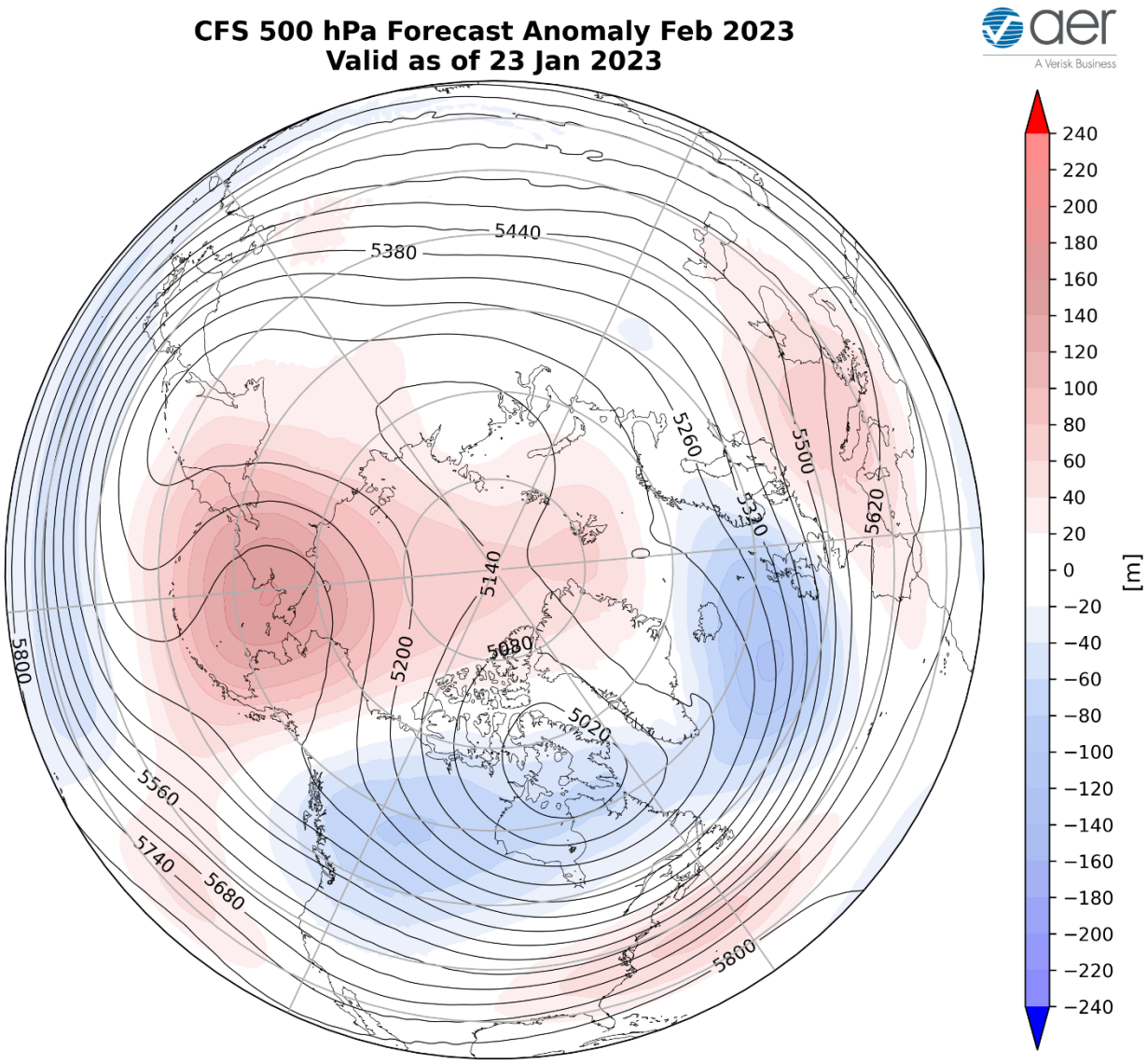

Figure 14. Forecasted average 500 mb geopotential heights (dam; contours) and geopotential height anomalies (m; shading) across the Northern Hemisphere for February 2023. The forecasts are from the 00Z 23 January 2023 CFS.

I include in this week's blog the monthly 500 hPa geopotential heights (**Figure 14**) and surface temperatures for February (**Figure 15**) from the Climate Forecast System (CFS; the plots represent yesterday's four ensemble members). The forecast for the troposphere is ridging across Southern Europe and stretching from the Aleutians, Eastern Siberia, Alaska and into the Barents-Kara Seas and off the US East Coast with troughing across Northwestern Europe, Northern and Eastern Asia, much of Canada and

the Western US (**Figure 14).** This pattern favors seasonable to relatively warm temperatures across Europe, Western and Southern Asia, Alaska and the Southeastern US with seasonable to relatively cold temperatures across Siberia, Northeastern Asia, much of Canada and the US (**Figure 15**).

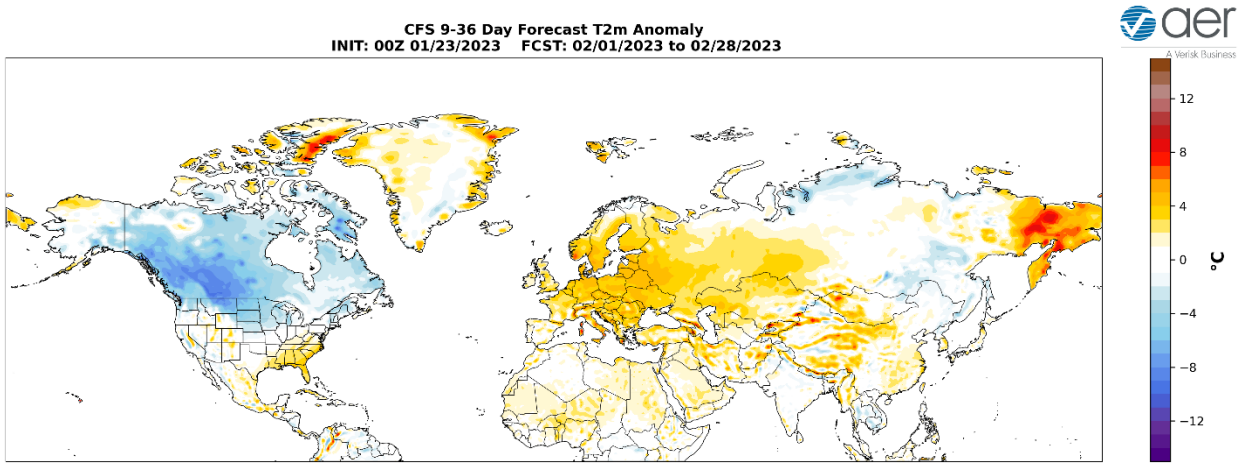

Figure 15. Forecasted average surface temperature anomalies (°C; shading) across the Northern Hemisphere for February 2023. The forecasts are from the 00Z 23 January 2023 CFS.

Boundary Forcings

Arctic Sea Ice

Arctic sea ice, which as expected is below normal (see **Figure 16**) but the regional anomalies have been more extensive in recent years. The greatest concentration of below normal remains in the Barents-Kara Seas, which I believe favors high latitude blocking. So it could be Arctic sea ice is increasingly favoring high latitude blocking in the Barents-Kara Seas region and PV disruptions.

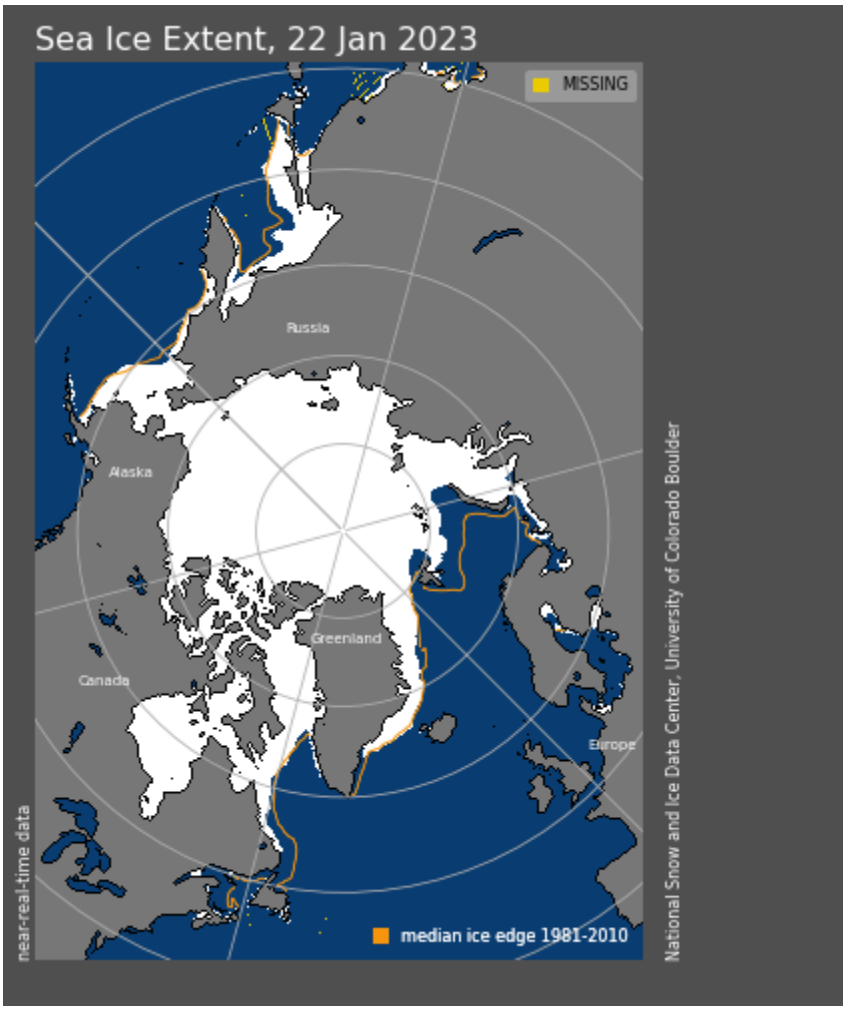

Figure 16. Observed Arctic sea ice extent on 22 January 2023 (white). Orange line shows climatological extent of sea ice based on the years 1981-2010. Image from the National Snow and Ice Data Center (NSIDC).

SSTs/El Niño/Southern Oscillation

Equatorial Pacific sea surface temperatures (SSTs) anomalies are below normal and we continue to observe weak La Niña conditions (**Figure 17)** and La Niña conditions are expected through the spring. Observed SSTs across the NH remain well above normal especially in the central North Pacific (west of recent years), the western North Pacific and offshore of eastern North America though below normal SSTs exist regionally especially in the South Pacific.

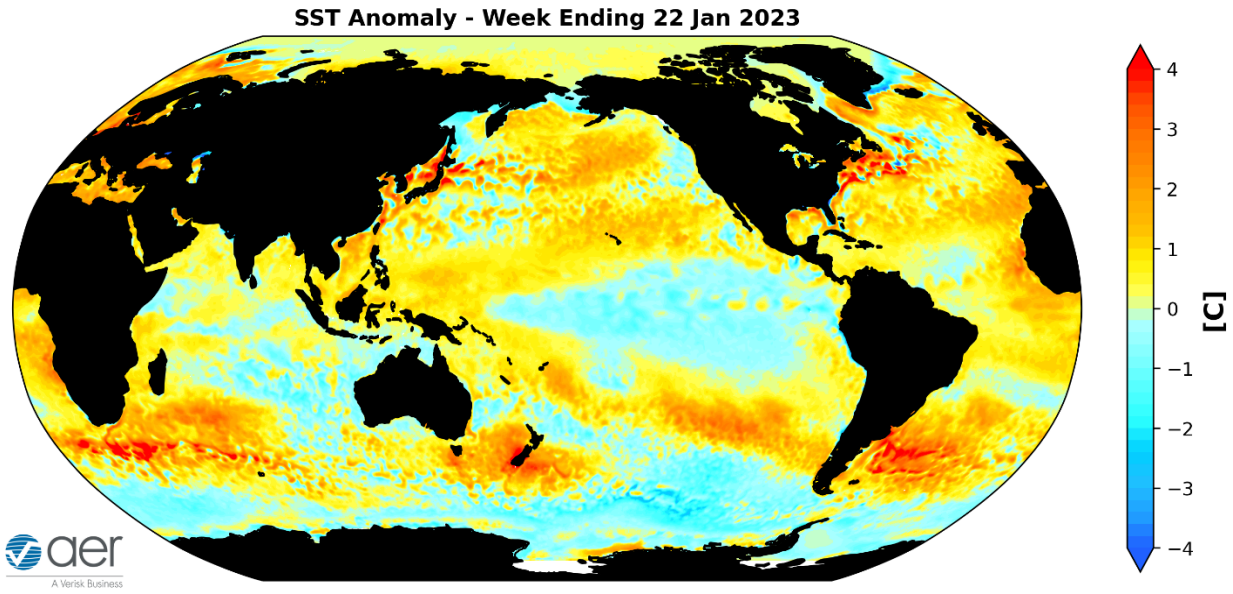

Figure 17. The latest weekly-mean global SST anomalies (ending 22 January 2023). Data from NOAA OI High-Resolution dataset.

Madden Julian Oscillation

Currently no phase of the Madden Julian Oscillation (MJO) is favored (**Figure 18**). The forecasts are for the MJO to remain weak where no phase is favored. The MJO is eventually predicted to emerge into phases two and three. Phase three favors troughing over Alaska, Western Canada and the Western US with ridging across eastern North America. Seems that the MJO is having little influence on the weather across North America in the short term. But admittedly this is outside of my expertise.

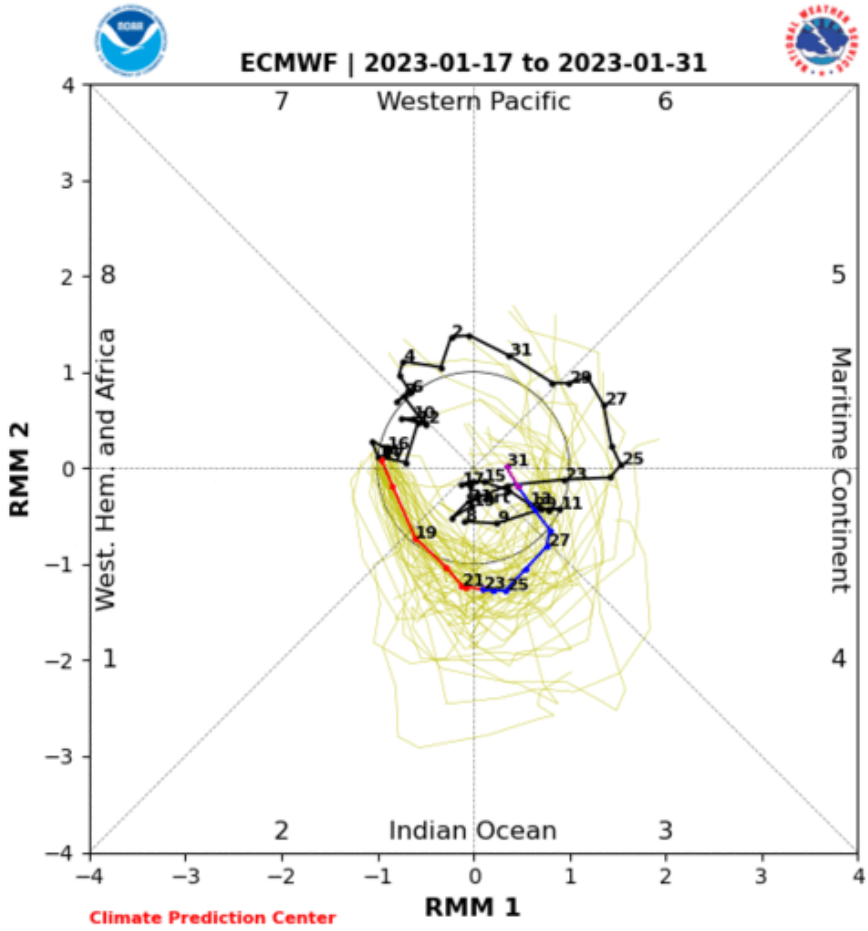

Figure 18. Past and forecast values of the MJO index. Forecast values from the 00Z 23 January 2023 ECMWF model. Yellow lines indicate individual ensemble-member forecasts, with the green line showing the ensemble-mean. A measure of the model "spread" is denoted by the gray shading. Sector numbers indicate the phase of the MJO, with geographical labels indicating where anomalous convection occurs during that phase. Image source: http://www.atmos.albany.edu/facstaff/roundy/waves/phasediags.html

Snow Cover

Snow cover extent (SCE) anomalies across the NH has advanced this past week mostly in North America where snow cover is normal to slightly above (see **Figure 19**). Snow cover is still above normal across China but less than last week. Snow cover extent is now above normal in Western Europe but remains below normal in Eastern Europe. I expect snow cover to advance in the coming weeks, especially across the US.

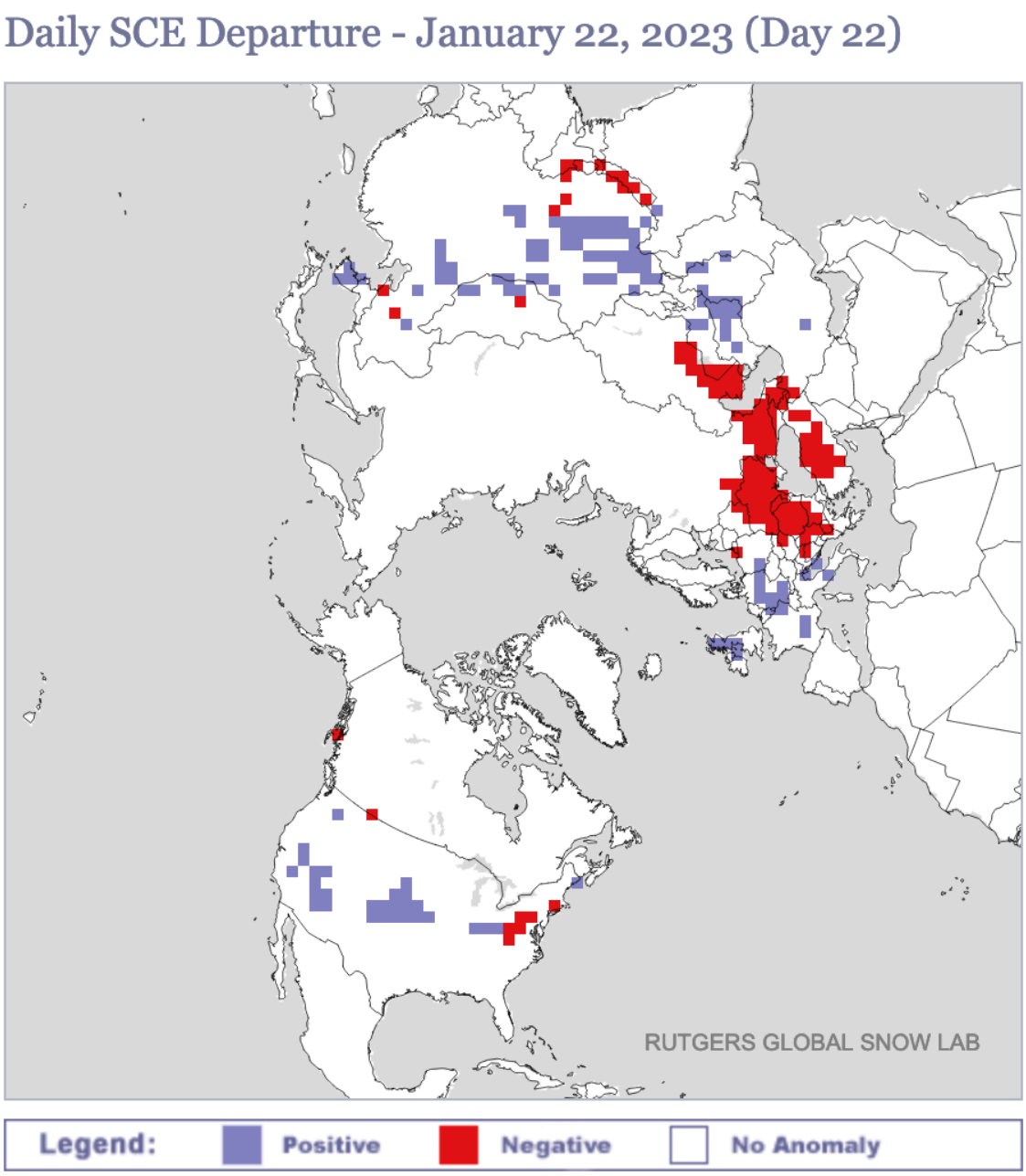

Figure 19. Observed North Hemisphere snow cover anomalies on 22 January 2023. Plot from https://www.star.nesdis.noaa.gov/smcd/emb/snow/HTML/snow_extent_monitor.html